LANSCE DIVISION TECHNOLOGY REVIEW

Short-Pulse Spallation Source Enhancement Project

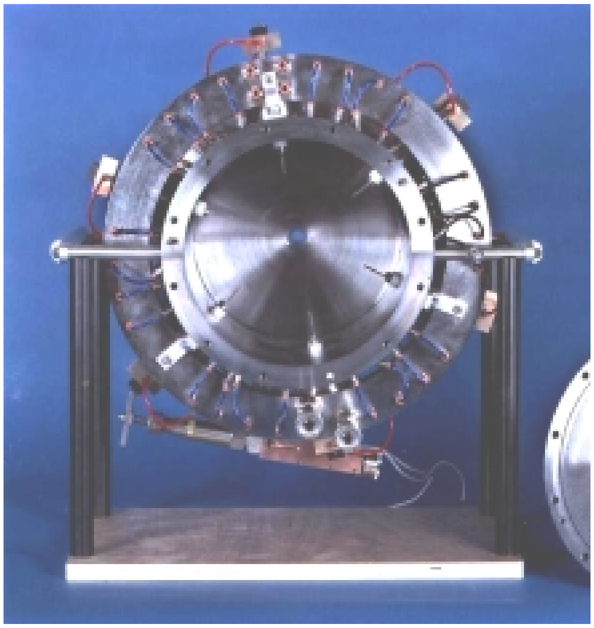
P.S. Lewis (LANSCE-DO)

The Short-Pulse Spallation Source Enhancement Project is significantly upgrading LANSCE capabilities by increasing the neutron source intensity and by constructing additional neutron scattering spectrometers. Because the facility improvements will support both the defense and basic research communities, this project is jointly funded by the Department of Energy Defense Programs (DP) and Office of Science (SC). DP is supporting accelerator improvements, which will increase the 800-MeV proton beam current delivered to the Lujan Center. SC is supporting the design and construction of new neutron-scattering spectrometers at the Lujan Center.

Accelerator Enhancement

The primary technical goal of the upgrade is to increase the average proton current delivered to the Lujan Center spallation target to 200 µA at a 30-Hz repetition rate to provide 160 kW of power to the target. To achieve this performance goal, the following major modifications to the LANSCE accelerator facilities are being carried out.

- The Proton Storage Ring (PSR) is being upgraded to handle higher accumulated charge levels. The upgrade includes a redesigned radio frequency (rf) buncher and modifications to the ring and 1L transport line to control instabilities and to minimize slow beam losses.
- A brighter H^- ion source for the accelerator is being developed in collaboration with Lawrence Berkeley National Laboratory (LBNL). In addition, the injector's 80-kV accelerating column and its high-voltage power and control systems are being upgraded to accommodate the new source.



▲ ***Fig. 1.*** *Photo of the new ion source designed and fabricated for LANSCE by LBNL.*

Ion Source and Injector Upgrade. The ion source (Fig. 1) and injector upgrade includes

- development and fabrication of axial proof-of-principle, prototype, and final production sources at LBNL with a technical goal of 20 to 40 mA H^- current at an emittance of 0.4 to 0.8 π mm-mrad, 95% normalized;
- construction, instrumentation, and validation of the Ion Source Test Stand (ISTS) at LANL;
- development of a new 80-kV column to accommodate higher source current;
- upgrade of the injector high-voltage power and control systems to accommodate the new source and column;
- system testing prior to installation; and
- installation and commissioning.

Development and fabrication of the ISTS source, column, and high-voltage power and control systems have been completed. In 2002, all of the hardware will be installed on the ISTS for long-term systems testing.

Proton Storage Ring Upgrade. The PSR upgrade includes

- a redesign and refurbishment of the rf buncher to increase its peak voltage from 12 to 18 kV (peak) and improve its reliability (Fig. 2),
- upgraded power and water utilities in the PSR,
- extensive PSR testing to identify means of controlling the PSR instability at accumulated charge levels of 6.7 µC and above,
- installation of multipole magnets and inductive elements in the PSR to control transverse instabilities,

▲ ***Fig. 2.*** *Refurbished rf buncher in the PSR.*

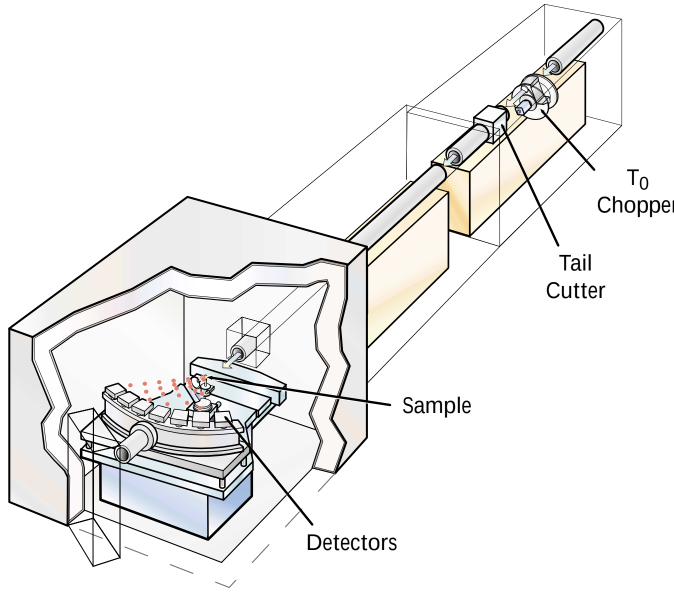
- titanium nitride (TiN) coating of key PSR vacuum chamber components to reduce electron multipactoring, and
- improvements to the 1L transport line to reduce losses that contribute to background radiation levels in ER-1 at the Lujan Center.

The buncher and utilities upgrades have been successfully completed. Tests have demonstrated control of the PSR instability to levels of up to 10 µC of accumulated charge. The design, installation, and commissioning of the PSR multipoles and inductors were successfully completed. The TiN-coated components are ready for installation. Design of the 1L improvements has been completed.

Spectrometer Development

The spectrometer development project has added three neutron-scattering instruments to the Lujan Center. The individual instruments were designed and constructed by collaborative spectrometer development teams involving participants from federal laboratories, universities, and industry. One of the instruments, the Protein Crystallography Station (PCS), is a structural biology spectrometer funded by the Office of Biological and Environmental Research (OBER). The Office of Basic Energy Science (OBES) funded the remaining two instruments: the Spectrometer for Materials Research at Temperature and Stress (SMARTS) and the High-Pressure Preferred Orientation Spectrometer (HIPPO).

Protein Crystallography Station. The PCS is a neutron diffractometer designed for structural biology (Fig. 3).



▲ ***Fig. 3.*** *Protein Crystallography Station beam layout. In ER-1, a composite T_0/T_1 chopper and a (proposed) tail-cutting device remove unwanted high- and low-energy neutrons, thus optimizing the neutron beam for high counting rates and low backgrounds at reasonable instrument resolutions. The vacuum pipe is tightly surrounded by heavy shielding until it reaches the sample position where the shield opens up to a large cave in ER-2. In the cave, neutrons interact with atoms in the crystal sample, are scattered, and are detected by a large two-dimensional cylindrical area detector. A k-circle goniometer moves the crystal and detector between about 30 different orientations. This feature enables all planes in the crystal to be brought into an orientation that will produce diffraction spots.*

The instrument is located on flight path (FP) 15 viewing a partially coupled high-intensity water moderator with beryllium reflector. The instrument includes a large position-sensitive two-dimensional detector, designed and fabricated by Brookhaven National Laboratory, that allows horizontal and vertical scans. Construction was completed in 2001 and the instrument is in its commissioning phase.

Spectrometer for Materials Research at Temperature and Stress. SMARTS is a powder diffractometer optimized to measure strain on both very large and small samples within a variety of sample environments (Fig. 4). The instrument has two principal modes of operation—strain scanning and material testing. In the strain-scanning mode, SMARTS is capable of measuring stress distributions in engineering components and other samples. In the material-testing mode, SMARTS can carry out measurements of materials under load, at high temperatures, and in controlled atmospheres. SMARTS is located on FP2 viewing a high-resolution water moderator. The instrument includes a neutron guide to enhance the flux on the sample, the capability of accommodating a sample with a total mass of at least 500 kg, and the capability of carrying out *in situ* strain measurements on samples at 180 kN and at 1500°C.

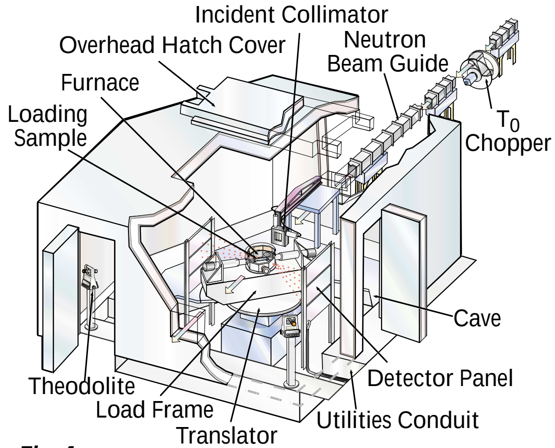


Fig. 4a

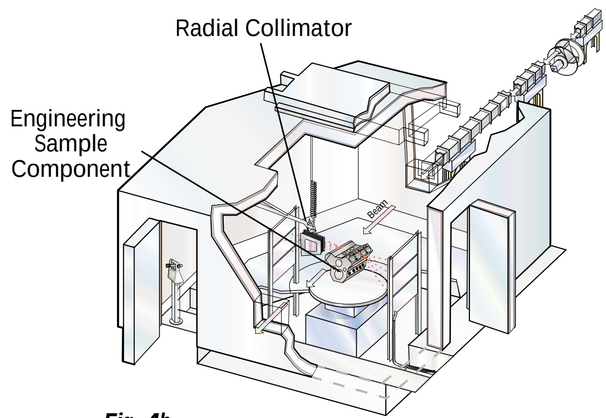
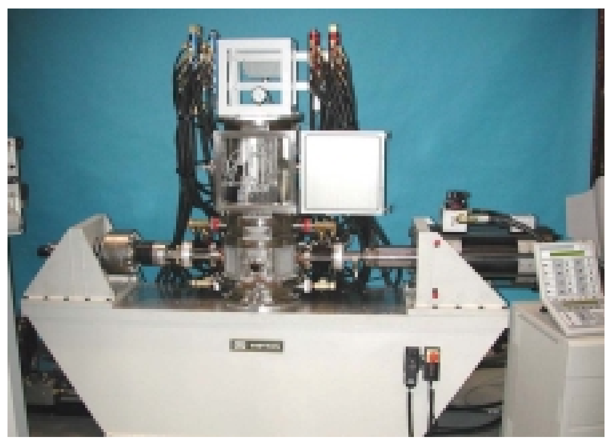


Fig. 4b

▲ ***Fig. 4.*** *SMARTS beam layout. Neutrons from the moderator pass through a series of collimating apertures before entering the neutron guide. In ER-1, a break in the guide accommodates a T_0 chopper, which removes fast neutrons and gamma flash that would otherwise contribute unwanted background. Slow thermal neutrons continue down the guide to the entrance of the SMARTS cave. On exiting the guide, neutrons pass to the center of the cave where some are scattered by the crystal structure of the sample to the detectors. Samples or ancillary systems are placed directly on the translator, which can accommodate up to 1500 kg, move in three orthogonal directions, and rotate about a vertical axis. Theodolites provide a precise optical triangulation and alignment capability for equipment or samples. Fig. 4a illustrates the load-frame-furnace suite in place. Note that there is no collimation between the sample and the detector. Fig. 4b shows a radial collimator between the detector and a generic engineering sample. When used with the incident collimation, selection of an appropriate radial collimator defines a sampling volume for spatially resolved measurements. (Note: Beam-line shielding is not shown.)*

▲ ***Fig. 5.*** *View inside the SMARTS cave, showing the translator mounted in the pit, one of the two banks of ^{3}He detector panels, and the incident beam collimation.*

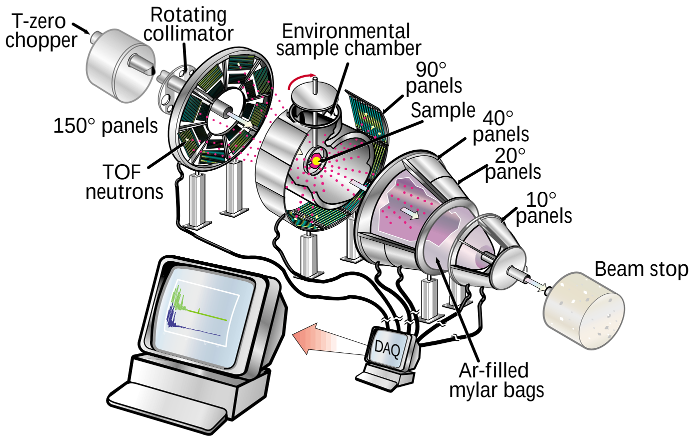


▲ ***Fig. 6.*** *Load frame and furnace set provides tension and compression up to 40,000 lb and temperatures up to 1500°C.*

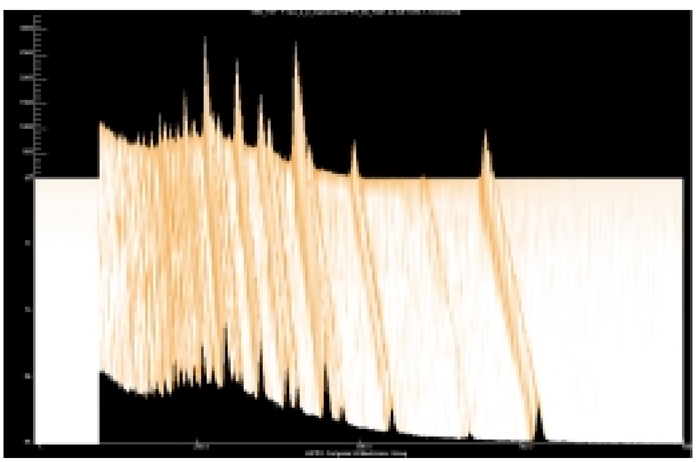
Fig. 5 shows a view of the translator mounted in the pit, one of the two banks of ^{3}He detector panels, and the incident beam collimation. Fig. 6 shows the load frame and furnace. Construction was completed in 2001, and the instrument is now in its commissioning phase.

High-Pressure Preferred Orientation Spectrometer. HIPPO is a high-intensity powder diffractometer designed for texture measurements (Fig. 7). HIPPO has the capability to study samples at high pressure and high and low temperatures. The instrument is located on FP4 viewing a high-intensity water moderator, and it includes detector banks at (nominally) 150°, 90°, 40°, 20°, and 10° (1,384 detectors, 4.6 m^2) and a sample changer capable of rapid interchange of samples.

A diffraction from a nickel test sample is shown in Fig. 8 below. Figs. 9 and 10 are photos of the HIPPO construction. Construction of HIPPO was completed in 2001, and the instrument is now in its commissioning phase.

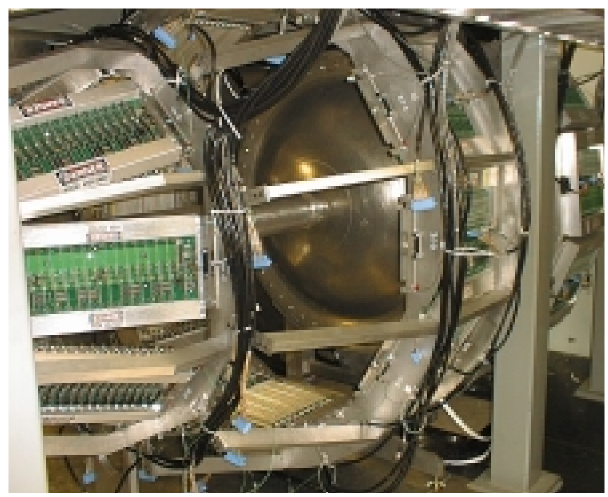


▲ ***Fig. 7.*** *Exploded view of HIPPO showing sample chamber surrounded by five conical three-dimensional rings of* ^{3}*He detector tubes in 10 atm. A white beam made up of pulsed neutrons of different energies (entering from the left) travels down a collimator to a chopper that cuts out very fast neutrons, allowing only slower thermal neutrons to continue down the FP to the bulk material contained inside a 29-in.-diam sample chamber. The neutrons interact with the lattice (crystal) structure of the bulk material, diffract off, and impinge on the detectors. Neutron diffraction is measured to ascertain how the energies or momentum of the neutrons changed after interacting with the atoms. (Note: Flight path and cave shielding are not shown.)*



▲ ***Fig. 8.*** *HIPPO diffraction pattern from a nickel test sample. This figure shows Bragg peaks from time-of-flight data taken from a nickel test sample. Data were taken from sixteen detector tubes on one of the HIPPO 90° panels.*

▲ ***Fig. 9.*** *Photo of the HIPPO sample chamber being installed in its cave.*



▲ ***Fig. 10.*** *View inside the HIPPO cave, showing the sample chamber, detector frame, and detector panels. Each detector panel contains an array of* ^{3}*He tubes, along with the supporting electronics and high-voltage power supplies.*

For more information about the Short-Pulse Spallation Source Enhancement Project, contact Paul Lewis (LANSCE-DO), 505-665-0932, MS H848, lewis@lanl.gov.

Produced by the LANSCE-4 communications team: Barbara Maes, Sue Harper, Garth Tietjen, Sharon Mikkelson, and Grace Hollen.

Los Alamos NATIONAL LABORATORY

A U.S. DEPARTMENT OF ENERGY LABORATORY
Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36.

LANSCE Los Alamos Neutron Science Center

http://lansce.lanl.gov